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No. 43: ON THE ROTATORY DISPERSION OF QUARTZ, BY H. F. DAWES.

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On the Rotatory Dispersion of Quartz.

By PROFESSOR H. F. DAWES, M.A.

Presented by Prof. J. C. McLennan.

(Read May 16, 1911.)

The following experiment constitutes a method of determining the Rotatory Dispersion of a substance, such as quartz, which has a relatively large rotatory power. In it light is detected by photographic means and the method is, therefore, applicable not only to wave lengths of the visible spectrum but also to the parts of the ultraviolet to which one may have access. An essential part of the arrangement of the apparatus consists of a spectrograph, so that the experiment may seem to illustrate the relative efficiencies of different types of apparatus in investigations ranging over a large part of the light spectrum.

The method depends on the use of a plate of the optically active substance which is sufficiently thick to rotate the plane of polarisation many times 180°. The rotation varies with the wave length and increased as the wave length decreases. If, therefore, for a certain wave length λo (in the extreme red, say,) there is a rotation A_o, there will also be rotations $A_o + 180$, $A_o + 2 \times 180$ . . . $A_o +$ n. 180 for wave lengths $\lambda_1, \lambda_2, \ldots \lambda_n$ which are [illegible] than λ_o and in decreasing order of magnitude. Hence, if the plate [illegible] substance is placed between analyser and polariser and if the [illegible] is set to extinguish the wave length y_o it will also extinguish the wave lengths $\lambda_1, \lambda_2 \ldots \lambda_n$, and in the spectrum of the analysed light there will be darkness at the positions of these colours.

In order to exhibit the relation between the rotation and the wave length, therefore, it will be necessary to determine the values of A_o, and of the various wave lengths coresponding [illegible] the places of darkness in the spectrum. The value of A_o, which is equal to $a +$ 180b (b a whole number, a less than 180°) may be obtained [illegible] direct saccharimetric measurement; a is given by the setting of [illegible] and b may be inferred from the thickness of the plate by [illegible] plates of small thickness. The values of the several [illegible] given at once by the calibration curve of the spectroscopic [illegible]

EXPERIMENTAL.

The rotation of the plane of polarisation was found for quartz using a specimen of thickness 3·85 cms. The sources of light used were (1) an ordinary electric arc and (b) a Leyden jar discharge between cadmium terminals. The former gives a very bright continuous visible spectrum and the latter is rich in ultraviolet giving a decided continuous background, while the cadmium lines serve for reference marks.

The light was polarised and anlaysed by means of fluorite plates placed parallel to one another and so arranged that the light was incident on each at the polarising angle $\tan^{-1}\lambda$, ($\lambda=1\cdot43$). Fluorite was used on account of its transparency to the ultraviolet, and also on account of the fact that there is but little variation in its index over a large range of wave lengths. The light was received by a spectrograph and the spectrum photographed with this arrangement of apparatus, the blackened parts of the negative or the white part of the positive correspond to wave lengths for which the rotation had been an integral number of times 180°.

Figure I shows two photographs of the spectrum made in this way, the one made by a quartz spectroscopic system and the other by a Uviol glass system; and the values for the rotations for a series of wave-lengths are shown in the following Table:—

No. of band.	λ x 10^7 mm.	Rotation per mm.	No. of band.	λ x 10^7 mm.	Rotation per mm.
1..........	7252	14·03°	22..........	2850	112·21°
2..........	6460	18·70	23..........	2800	116·88
3..........	5670	23·38	24..........	2755	121·56
4..........	5190	28·05	25..........	2715	126·23
5..........	4860	32·73	26..........	2675	130·91
6..........	4595	37·40	27..........	2635	135·78
7..........	4355	42·08	28..........	2600	140·26
8..........	4155	46·75	29..........	2565	144·93
9..........	3980	51·43	30..........	2535	149·61
10..........	3830	56·10	31..........	2505	154·28
11..........	3700	60·78	32..........	2480	158·96
12..........	3590	65·45	33..........	2455	163·64
13..........	3480	70·13	34..........	2430	168·31
14..........	3380	74·81	35..........	2405	172·99
15..........	3290	79·48	36..........	2380	177·66
16..........	3210	84·16	37..........	2355	182·34
17..........	3140	88·83	38..........	2330	187·01
18..........	3070	93·51	39..........	2310	191·69
19..........	3010	98·18	40..........	2290	196·37
20..........	2950	102·86	41..........	2270	201·04
21..........	2900	107·53			

Various formulæ have been proposed to express the rotatory dispersion of optically active substances. Two types in which the numbers refer to a quartz plate of thickness one millimeter are as follows:—

$$(a)\quad R = \frac{7\cdot1083 \times 10^{-6}}{\lambda^2} + \frac{0\cdot1477 \times 10^{-13}}{\lambda^4} \quad \text{(Boltzmann).}$$

$$(b)\quad R = -1\cdot581 + \frac{8\cdot0403 \times 10^{-6}}{\lambda^4} \quad \text{(Stefan).}$$

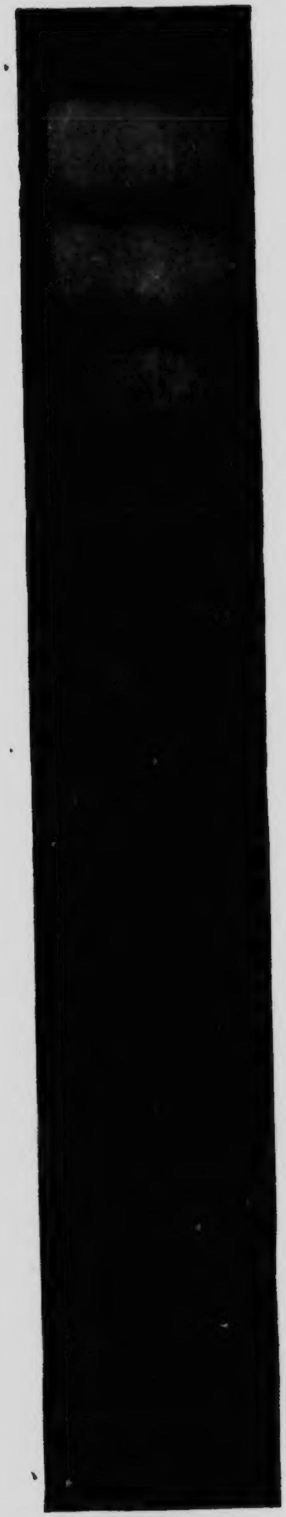
The following table illustrates the variation from the observed values of the values calculated by means of these formulæ:—

Wave-length $\times 10^7$ mms.	Observed	Rotation	
		Formula *a*	Formula *b*
8000	11·38	11·46	10·98
7000	15·20	15·13	14·83
6000	20·75	20·88	20·75
5000	30·82	30·54	30·58
4000	50·50	50·19	48·67
3500	68·40	67·86	64·05
3000	98·6	77·23	87·75
2500	154·2	151·53	127·07
2100	249·0	237·16	180·77

The two constant formula developed by Drude from a consideration of the action of free electrons in the quartz on the light waves passing through a plate, viz.:

$$R = \left\{ \frac{12\cdot200}{\lambda^2 - \lambda_1^2} - \frac{5\cdot046}{\lambda^2} \right\} 10^{-6}$$

seems to give almost perfect agreement over the whole range of wave lengths. (λ_1, is the wave length corresponding to the set of free electrons whose periods are nearest to those of the light waves.)



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